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AMERICAN
INDUSTRIAL HYGIENE
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Volume 10 SEPTEMBER, 1949 Number 3

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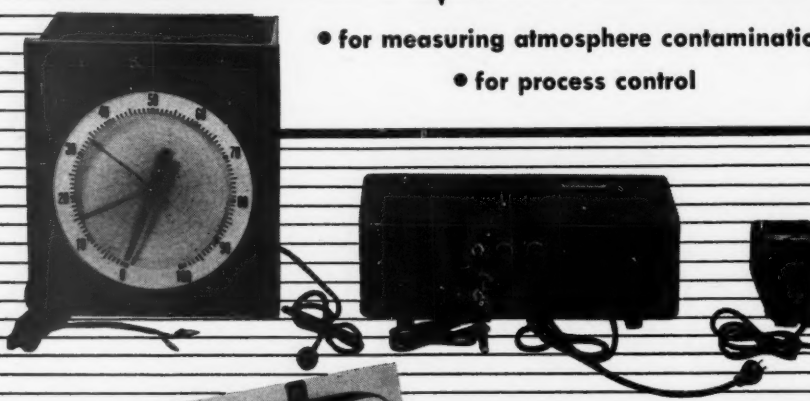

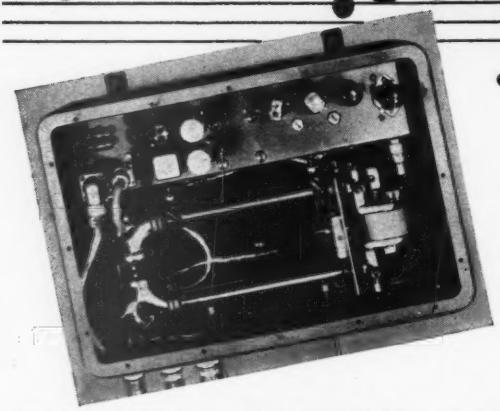

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Volume 10 SEPTEMBER, 1949 Number 3

A Ten-Year Study of Butyl Alcohol Exposure

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Introduction

NORMAL butyl alcohol is used in a wide variety of industrial operations. The estimated production figure in the U. S. for 1948 was 141 million pounds.[1] In many industrial operations, where butyl alcohol is used as a solvent, it is ultimately recovered and re-used—making the total quantity in actual use considerably greater than the annual production figure.

In spite of the very great opportunity for exposure to the vapors of butyl alcohol in a number of conditions where the solvent is volatilized as an essential part of the process (in painting and lacquering, in coating operations) no instance of systemic intoxication to n-butyl alcohol vapor has been reported in the industrial medical literature.[2,3,4] A few cases of systemic intoxication have been associated with solvent mixtures, of which butyl alcohol was a constituent, but the role of n-butanol in these instances has not been defined.

Irritation of the eyes due to the vapors of butyl alcohol has been reported by Tabershaw et al[5] and by Krüger,[6] although the latter experience was with mixed solvents. The only report in which the environmental factors were quantitatively related to the irritation effect was by Tabershaw et al. They observed eye inflammation associated with butanol concentrations above 50 p.p.m., but concluded that systemic effects would not be expected if concentrations were kept below 100 p.p.m.

The sensory response to butyl alcohol vapor was determined by Nelson et al[7] who reported that for short exposures, eye irritation was associated with 50 p.p.m., nose and throat irritation with 25 p.p.m. and that "less than" 25 p.p.m. was the highest concentration which the majority of the experimental subjects estimated as satisfactory for an eight-hour exposure.

The latest and probably the most widely accepted tabulation of maximum allowable concentration values, the "1948 M.A.C. Values" submitted by the Committee on Threshold Limits and accepted by the American Conference of Governmental Industrial Hygienists at the 1947 meeting[8] lists the M.A.C. for n-butanol at 50 p.p.m. In Cook's compilation of Maximum Allowable Concentrations[9] there is reference to the levels accepted or suggested by several agencies:

200 p.p.m.—California Industrial Accident Commission, September, 1945.
New York State Dept. of Labor, June, 1945.
100 p.p.m.—Utah Dept. of Health, 1945.
U. S. Public Health Service, September, 1945.
50 p.p.m.—Massachusetts Dept. of Labor and Industries, 1945.

Cook concluded that 50 p.p.m. should be accepted. Much earlier, Lehmann and Flury[2] had suggested 100 p.p.m.

With this obvious discrepancy in suggested levels and with the inconsistency between the "comfort" levels for certain other solvents designated in Nelson's study and those encountered in critically evaluated

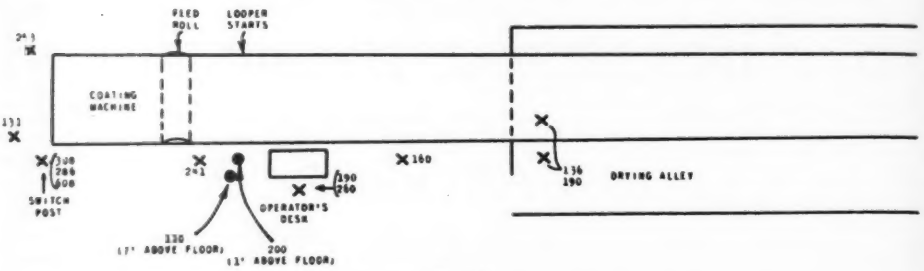

Fig. 1.
n-Butanol Concentration. Baryta Coating Operation

plant experience (for example, acetone) it is apparent that more information is needed properly to assess a safe and comfortable working level or "maximum allowable concentration" for n-butyl alcohol.

Experimental

A STUDY has been made over a 10-year period of an n-butyl alcohol exposure in a baryta coating operation, with repeated measurements of environmental factors, absentee data, and clinical examinations of the exposed individuals. This data is presented, correlated, and evaluated below.

A. Evaluation of Environmental Factors.

1. *Description of Operation:*

A baryta coating is the white, opaque layer applied to photographic paper upon which is coated the light sensitive emulsion layer. The chief constituent is barium sulfate. The coating suspension contains varying quantities of n-butyl alcohol which is evaporated with the other solvents (chiefly water), and this volatilized butyl alcohol is the source of the vapor exposure described in this study.

The coating and drying operations are shown schematically in Fig. 1.

The paper unrolls from a stock roll, moves forward to the coating pan where the liquid coating is applied, then upward and backward over the stock roll. The coating machine is about seven feet long. Just beyond the stock roll, the paper is picked up by a series of "loopers" and carried some 20 feet to the start of the drying alley. The coating operator or "coater" spends about 80% of his time at three positions near the coating machine, with another 10% in the drying alley.

The solvent vapor concentrations in the vicinity of the coating machine show a diminishing gradient away from the coated surface of the paper, but this is modified by the fact that there are a number of coating machines, side by side, separated from each other by a narrow aisle. Values from one set of measurements at representative points made during the earlier years of this study, are shown in Fig. 1. All values are taken at breathing zone levels excepting as specifically indicated.

2. *Concentration of n-Butanol:*

Measurements of the concentration of n-butanol vapors have been made at fairly

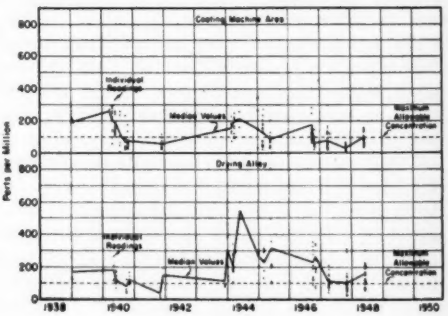

Fig. 2.
n-Butanol Concentration

frequent but irregular intervals from 1938 to the present. These are all "breathing zone" values, and have been taken consistently at areas where the operator spends the majority of his working time. They are shown graphically in Fig. 2. The upper graph contains the measurements made near the coating machine (about 80% of operator's working time). The lower chart shows the values in the drying alley (about 15% of the operator's working time). The solid line connects the median value of each scat-

ter of determinations. The dotted line indicates the 100 p.p.m. concentration, the value arbitrarily selected as a reasonable operating level.

Initially, the results exceeded an average of 200 p.p.m., but these were reduced by lowering the concentration of butanol in the coating suspension and by the introduction of additional ventilation to an average, over the study period, of about 100 p.p.m. The data, in our opinion, characterizes as accurately as possible the actual levels of butanol vapor to which the operators were exposed.

3. *Determination of Butyl Alcohol:*

The interferometric method used for determining butyl alcohol in this study has been checked repeatedly, both as to the efficiency of collecting the sample and the final determination. A measured amount of air containing the butanol vapor is passed through silica gel in "U" tubes. The silica gel is then transferred to a glass-stoppered distillation apparatus, water is added, and the butyl alcohol-water solution distilled into a receiver in an ice bath. The distillate is made up to a known volume and the readings made in a Zeiss liquid interferometer, previously calibrated with known butanol solutions. The concentration in the air sample is then readily calculated. Good agreement was obtained with results by the chromic acid oxidation method.

On repeated occasions, samples were taken at the actual nose level of the operator. In this technique, the silica gel is contained in a brass tube attached to a headband which the operator wears. The actual point of sampling is within two or three inches of the operator's nostrils. The line drawing the air through the sampling tube is a long length of rubber hose, permitting considerable latitude in the movements of the operator around the coating machine. Measurements made by this technique agree surprisingly well with the averaged values made by holding the U-tube sampler at breathing zone level at the three sites where the operator spends most of his time.

B. Evaluation of Effects on Exposed Personnel:

1. *Description of personnel and disposition of exposed subjects over the period of this study:*

At the start of this study 16 individuals were exposed to the vapors of butanol as baryta coaters. The number increased to a maximum of 99 at the time of the 1946 sampling. The original 16 were followed as a group so long as they continued on the coating operation. By 1946 only 10 of this group remained as "coaters," and at present only four are employed in this capacity.

The physical and mental requirements for individuals assigned to the baryta coating operation are similar to those applying in other plant operations in the "skilled-labor" category. Certain brief phases of the operation, for example, the placing of a new stock roll of paper, require considerable physical effort. For this reason, an arbitrary age limit of 55 is enforced, with operators who have not been transferred or promoted to other operations prior to this time, automatically assigned to other and less physically exacting work in the department.

The following describes the disposition of the original exposed group. When the first physical and laboratory examinations were made as a part of the study of the effects of butyl alcohol exposure, 16 men were employed as coaters on machines using butyl alcohol in the coating solutions. Of this group, 15 are still at work in the plant, with one individual retired three years ago at age 65, the normal retirement age in the plant. Of the remaining 15: four are still working as coaters; five were promoted during the 10-year period to supervisory jobs; five were automatically transferred to other work at age 55; one was transferred at his request. The latter instance occurred about two years after this study was started—and while the concentration of butanol vapor was averaging about 200 p.p.m. Objection to the vapors was a questionable part of his real reasons for transfer.

2. *Absenteeism of Butyl Alcohol Exposed Employees:*

The 10-year records for total absence and for absence due to illness are shown in Table I and graphically in Fig. 3. In Table II and Fig. 4 the ratios of absence due to illness and total absence for the total male plant population and the butyl alcohol exposed group are presented. The population characteristics of the butyl alcohol exposed group are sufficiently comparable to that of the total male population, to permit the con-

TABLE I.
TOTAL ABSENCE AND ABSENCE DUE TO ILLNESS FOR TOTAL PLANT MEN AND FOR MEN EXPOSED TO BUTYL ALCOHOL TERMS OF HOURS PER MAN PER YEAR
1939-1948

	Total Plant Men		Men Exposed to Butyl Alcohol		
	Total Absence	Absence Due to Illness	Total Absence	Absence Due to Illness	No. of Men Exposed to Butyl Alcohol
1939	42	27	19	6	15
1940	46	29	8	4	15
1941	48	30	38	28	15
1942	55	34	9	4	15
1943	93	54	28	12	15
1944	121	63	70	39	52
1945	129	76	51	19	57
1946	98	59	52	23	99
1947	91	53	71	46	111*
1948	83	53	35	20	59

*The 1947 group of exposed men consists of men from the 1946 and 1948 group of exposed men.

Note: Hours of absence include overtime hours that men would have put in if they had been at work. This fact tends to increase the hours of absence during intervals of high overtime work, such as during the war.

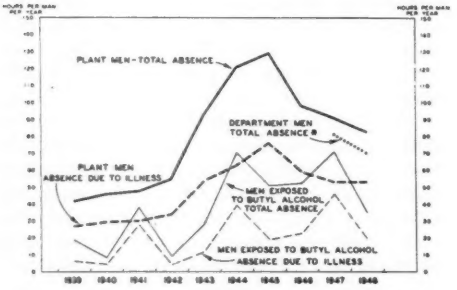
PLANT MEN-TOTAL ABSENCE
DEPARTMENT MEN TOTAL ABSENCE *
PLANT MEN ABSENCE DUE TO ILLNESS
MEN EXPOSED TO BUTYL ALCOHOL TOTAL ABSENCE
MEN EXPOSED TO BUTYL ALCOHOL ABSENCE DUE TO ILLNESS

Fig. 3.
Total absence and absence due to illness for plant men and for men exposed to butyl alcohol

* The men exposed to butyl alcohol work in this department.

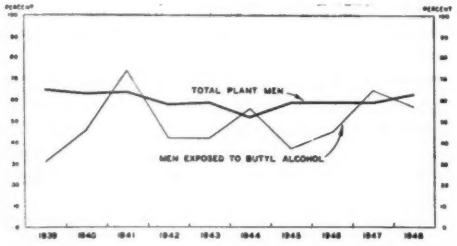

Fig. 4.
Absence due to illness as a percent of total absence for total plant men and for men exposed to butyl alcohol

clusion that exposure to the concentrations of n-butanol vapor described above are not associated with an increase in total absence, absence due to illness, nor in a significant variation in the ratio of these absence rates.

TABLE II.
PER CENT OF ABSENCE DUE TO ILLNESS RELATIVE TO TOTAL ABSENCE FOR TOTAL PLANT MEN AND MEN EXPOSED TO BUTYL ALCOHOL

	Total Plant Men % of Absence Due to Illness to Total Absence	Men Exposed to Butyl Alcohol % of Absence Due to Illness to Total Absence
1939	65%	31%
1940	63%	46%
1941	64%	74%
1942	58%	42%
1943	59%	42%
1944	52%	56%
1945	59%	37%
1946	59%	45%
1947	59%	65%
1948	63%	57%
Avg. 1939-1948	59%	54%

3. *Clinical Examination of Exposed Individuals:*

(a) Physical Examination:

The physical examinations of employees exposed to butyl alcohol have been negative for any signs which could be related to exposure with the exception of eye irritation associated with the higher concentrations (averaging 200 p.p.m.) encountered during the earlier period covered by this study. Since the exposure level has been reduced to 100 p.p.m., there have been very few complaints of irritation—and those were associated with short runs of coating types where the concentration frequently exceeded 100 p.p.m. In these mild cases the symptoms were of short duration (a few hours at the most) and examination of the conjunctiva and cornea showed only slight edema.

TABLE III.
MEAN VALUES FOR HEMOGLOBIN, ERYTHROCYTES AND HEMATOCRIT FOR ORIGINAL AND TOTAL GROUPS EXPOSED TO N-BUTANOL

	"ORIGINAL" EXPOSED GROUP				TOTAL EXPOSED GROUP			
	No. in Group	Hb.	Erythrocyte Count	Cell Volume (Hematocrit)	No. in Group	Hb.	Erythrocyte Count	Cell Volume (Hematocrit)
July 1939	15	15.5	4.98	47.6				
July 1943	15	16.0	5.39	47.9				
Oct. 1943	15	15.7	5.34	47.1				
Oct. 1944	14	15.5	5.50	46.9	52	15.6	5.62	46.7
May 1945	11	15.9	5.42	47.9	57	15.7	5.53	47.4
Oct. 1946	10	15.4	5.40	47.9	99	15.5	5.52	47.0
Nov. 1948	4	15.9	5.41	46.0	56	15.5	5.54	47.1

The earlier cases were of greater severity, occasionally sufficient temporarily to limit the ability to work. Even at levels above 200 p.p.m. only occasional individuals developed increasing blurring of vision, lacrimation, photophobia—beginning about the middle of the work week and growing more severe toward the end of the week. At the time of these complaints, the work week was 48 hours, or more. Examination of the eye by the ophthalmologist revealed slight to moderate corneal edema, with injection and mild edema of the conjunctiva. In every instance the condition had subsided over the week end. The occurrence of these few cases, however, stimulated a more thorough study and was an important factor in bringing about the reduction of the vapor levels.

(b) X-rays of the Lung:

For a period of several years at the beginning of the 10-year study serial chest x-rays were made of all members of the group. These roentgenograms were negative for any effect which could be associated with butyl alcohol vapor exposure.

(c) Clinical Laboratory Examinations:

Seven serial studies were made of the exposed group over the 10-year period. As the number in the exposed group increased, analyses were made of the total group, and separately of the original group still employed as coaters. Each set of data was analyzed and statistically compared with plant control values and with the previous results from that group. In no instance, except one, was there a significant deviation from the plant normal. This was the initial mean erythrocyte count value, obtained on the group of 15 original "exposed" employees. Since the hemoglobin and cell volume mean values were "normal," and since all subsequent erythrocyte mean values were within the limits of normal, the significance of this one deviation is not clear. The mean values for hemoglobin, erythrocyte count and cell volume measurements for the original group of 15 "exposed" employees and for total group of exposed employees are shown in Table III. In each examination, in addition to the hemoglobin, erythrocyte count and cell volume, a measurement of leukocyte count, differential leukocyte count, icterus index, sedimentation rate, and complete urinalysis was made. In later studies various tests such as the thymol-barbitone precipitation and the cephalin-cholesterol flocculation were applied, and these, as for the other characteristics above, gave results within normal limits. In Table IV are shown the mean values for the October,

TABLE IV.
CLINICAL LABORATORY DATA
MEAN VALUES — ALL CHARACTERISTICS
FOR "ORIGINAL" EXPOSED GROUP, 1943 AND 1948 AND FOR TOTAL EXPOSED EMPLOYEES, 1948

YEAR	1943		1948
	"Original" Exposed Group	Total Exposed Group	Remaining of "Original" Exposed Group
No.	15	56	4
Hb.	15.65	15.48	15.9
RBC	5.34	5.54	5.41
Cell Vol.	47.1	47.1	46.0
MCH	29.1	47.1	46.0
MCV	88.3	86.5	85.5
MCHC	32.1	32.9	34.3
WBC	8,115	8,210	8,800
Polys	57	59	64
Lymphs	32.5	34.5	27.5
Monos.	7	4	5.5
Eos.	3	2	2.5
Baso.	0.5	0.5	0.5
Ict Ind.	3.2	3.6	3.5
Sed. R.	10.9	9.2	7.5

1943, and 1948 examinations, as representative of the results. It must be concluded that exposures to concentrations of n-butyl alcohol of 100 p.p.m. for a 10-year period are not associated with any significant changes of these common clinical laboratory characteristics.

Discussion

IN THE establishing of a Maximum Allowable Concentration value, the approach can be made from two directions: (1) from above downward—that is, by determining the lowest level which is associated with positive, untoward findings, and (2) from below upward, with the assumption, of course, that there are minimal levels at which no harmful or uncomfortable effects will occur. These two directional approaches hold regardless of the criteria finally used to determine the limit, whether actual injury as indicated by clearly demonstrable physical *signs*, or by the less easily assessable *symptoms*, or the even more arbitrary standard of *comfort*.

The critical evaluation of physical signs, particularly if corroborated by quantitative measurements, permits a more accurate correlation with the environmental factors. The interpretation of symptom complexes is much more difficult, and there is apt to be much less agreement on an association with specific concentration levels. When "comfort," or the converse, "discomfort," is the measure applied, the disparity of opinion is apt to be even greater.

In general, however, the one relatively fixed point in establishing an M.A.C. is the level which is associated with a positive finding of physical signs, symptoms or discomfort. Frequently, from this point on, the question of fixing some lower value which will be free from this physiological or psychological effect becomes one of introducing a factor-of-safety, and necessarily an arbitrary action. Thus when the suggested maximum allowable concentration is predicated upon, first, an association with a symptom complex or discomfort factor which is extremely difficult to interpret, and second, a factor-of-safety divisor which is quite arbitrary, it is easily understood why there may be disagreement over the acceptance of a particular standard.

The development of information establishing an M.A.C. "from below" is most important if the finally accepted standards are to be accurate, reasonable, and practical. Several factors have combined to minimize the presentation of this type evidence.

A major difficulty lies in the fact that such data, to be convincing, must be much more complete than that establishing the association with a positive finding of injury. "Testimonial" evidence from workmen, supervisors, employers, and suppliers of the material in question, may serve as a starting point in assessing the hazard, but in themselves should carry little weight without corroboration by adequate studies.

A second deterrent has been the difficulty of getting such data published in scientific journals. The reception, by editors, of such "negative" studies has been poor, although the recent controversy over maximum allowable concentration values has opened a market for such data.

Consequently,although there must be a very large amount of such information buried in the files of the industrial hygiene organizations throughout the country, much of it has not been organized for publication. This study, which was initiated as a simple control unit of our general industrial hygiene program serves as a good example. If the lowering of the maximum allowable concentration value had not extended to a point of conflict with the conclusions of this study, it is unlikely that this data would have been presented.

There is no immediate explanation for the different conclusions developed by the Tabershaw[5] and by the Nelson[7] studies, and this work. The apparently more severe eye injury reported by the Massachusetts investigators was not encountered here although our studies extended over a much longer period.

The discrepancy between the "comfort" levels reported by Nelson et al[7] and those accepted by plant employees is more easily resolved. In our experience, there are numerous instances of plant employees readily accepting concentrations which are initially irritating and objectionable to the casual visitor or to office workers. In a number of cases, employees have strenuously objected to being transferred from work areas where there was a constant exposure to these "uncomfortable" concentrations, even though they would not suffer economically

in the transfer. The examination of these employees had not revealed any greater incidence of inflammation of the eyes or upper respiratory tract, excepting in a few instances as reported above, when higher vapor levels were encountered. All of the members of our industrial hygiene environmental unit have spent considerable time in these "controversial" concentrations of butyl alcohol and are unanimous in concluding that after a short acclimatization, the conditions are not uncomfortable. In evaluating an environment, we ask, would we be willing to work under these conditions; would we feel that the employer was reasonable in asking it? Our answer, with the premise of "100 p.p.m. of n-butanol vapor in the breathing zone," would be, yes.

It should be obvious that lower concentrations of n-butanol than 100 p.p.m. should be maintained if they can be reasonably and economically achieved. In the opinion of the authors, however, there is no hazard associated with concentrations up to 100 p.p.m., and the inclusion of values lower than 100 p.p.m. in governmental-regulatory codes with the implied or actual legal authority of such figures, is not justified by the evidence available.

Summary

A 10-YEAR study of men exposed to the vapors of n-butyl alcohol (n-butanol) in a baryta coating operation is reported. The initial group of 16 was gradually increased to about 100.

2. Concentration values of butyl alcohol in the breathing zone of the operators initially averaged slightly greater than 200 p.p.m. The levels were subsequently lowered so that the mean value over the greater part of the ten year period was about 100 p.p.m.

3. No eye injuries or symptoms were found in any individual at the concentrations averaging 100 p.p.m. With concentrations averaging above 200 p.p.m. transient corneal inflammation, with associated burning sensation, lacrimation, and photophobia was encountered in occasional workmen.

4. No systemic effects have been observed, as measured by serial physical examinations, chest x-ray, and a fairly comprehensive clinical laboratory examination. A deviation of the mean erythrocyte count was found on the first examination, 10 years ago, but with the associated normal hemoglobin and cell volume values, and the absence of this deviation on all subsequent examinations, the significance is questionable.

5. The record for total absence and for absence due to illness is considerably better for the butyl alcohol exposed group than for the total plant. The ratio of absence due to illness to total absence is about the same as that for the total plant male population.

6. Complaints, either unsolicited or on direct question, of irritation or disagreeable odor associated with the 100 p.p.m. exposure level have been rare. The records show only one transfer among several hundred individuals assigned to the operation for reasons of disliking the solvent odor. It is the unanimous opinion of the industrial hygiene environmental unit personnel that 100 p.p.m. is not an unreasonable, impractical, or objectionable concentration for continuous industrial exposure.

7. It is the opinion of the authors that there is no hazard associated with concentrations of n-butyl alcohol up to 100 p.p.m., and that the inclusion of values lower than 100 p.p.m. in governmental regulatory codes is not justified by the evidence.

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The Industrial Hygiene Program of the American Cyanamid Company

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INDUSTRIAL HYGIENE seeks to provide better, more healthful environmental conditions for people at their place of employment. Any venture based on this philosophy as a major premise is fundamentally sound and therefore headed for success. Likewise the application of this premise to industrial production will bring definite rewards, those readily observable and those less tangible.

Not long ago, we received a typical hygiene request over the telephone. A department head at one of our plants called to advise us that he was ready for full scale production of a product for which we had given specific health maintenance recommendations during the pilot processing. Now he wanted us to review the installation before starting actual production, and to advise on any additional steps that should be taken to maintain a desirable work environment. In our earlier investigation we had suggested a minor process change, the application of local exhaust ventilation and the provision of a scrubber for exit gases, vapors and dusts. We found that these changes had resulted in a system which was practically leak proof, thereby assuring maximum protection to our employees. Production from the start was entirely free from employee discomfort or illness. Such calls as this demonstrate part of the service extended by our industrial hygiene group in the production of chemical products. Likewise demonstrated is the intangible benefit of preventive hygiene and the importance of avoiding possible trouble.

This discussion does not present an audit of accomplishments nor does it attempt to assign a dollar value to the prevention of occupational illness. Rather the purpose is to state briefly how industrial hygiene may serve a company in its manufacture of extremely diversified chemicals and in the sale of these products when some degree of toxicity is involved.

As you are aware, industrial hygiene brings together certain skills from several fields of science. It applies this pool of knowledge to the task of improving the conditions of work, improving plant environment and also the stature of a plant as a neighbor in its community. All of this is from the standpoint of maintaining the health and well-being of employees within the plant, and the comfort of those who live nearby.

In the American Cyanamid Company, industrial hygiene is a function of the central medical department. Here it enjoys perfect liaison, which the medical director has made possible, with all central office groups, all plants, their management personnel, their medical departments and their employees. It appears quite likely that only under such ideal liaison may industrial hygiene serve in full measure. At least this is true in our experience where there are no lines of cleavage to present a hurdle nor barricades of politics or strict inter-departmental disciplines. While various groups in the company seek information from us in industrial hygiene, we, in turn, depend on them for certain facts and figures so that our free liaison is very important. It is thus possible to sit down together in conference about a problem with such groups as technical, research, engineering, production, sales and safety, and have the benefit of their considerations.

Cyanamid has long been conscious of the value of industrial hygiene but six years ago marked the inauguration of a formal program. Since that time this program has grown through requests for aid as well as through routine plant studies till it now includes the work of several persons, both part time and full time. Previously much had been accomplished toward the improvement of working conditions but frequently, as has been the history with many other companies, these benefits accrued as a result of necessity. Now an evaluation of the plant environment pointing out the potential exposure for employees has brought

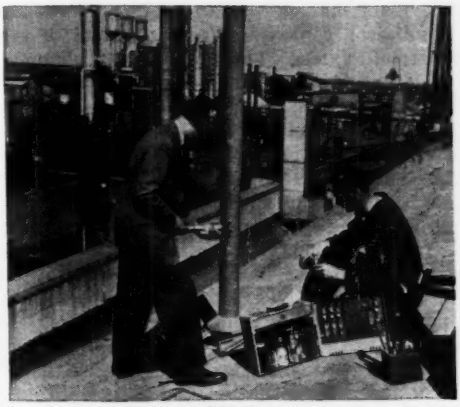

Fig. 1.
Air pollution prevention comes under the realm of Industrial Hygiene at the American Cyanamid Company. Here stack sampling is being conducted to determine the nature and quantity of "airfluent"

emphasis and new meaning to the expenditure of money in this direction. The value to be received for such expenditure can now be foreseen.

A Two-fold Program

Basically, our program is two-fold: correcting conditions that already may exist, and preventing the occurrence of new, undesirable situations when processes are changed or new processes are developed and installed. Attached to this main program are a number of other areas of service to be referred to later.

We are in an advantageous position since we can follow the development of new chemicals in the research laboratory. As the nature of these chemicals unfolds and as plans are laid for pre-pilot and pilot plant construction, industrial hygiene enters the picture. We take the information that is being gathered in animal toxicological studies and apply the necessary environmental control to the blueprints of the new process. This is true preventive industrial hygiene. The experience gained in following pilot plant operations is transposed to the blueprints for the complete production plant. Protection of employee health is thus secured in advance. In addition, particularly where toxic substances are to be produced, we attend the start of such new processes to look for potential hazards.

Our programs in various plants are usually headed by engineers who carry out the design and installation of corrective measures under the direction and advices of the central office industrial hygiene group. Under these men, in turn, are draftsmen, who prepare completed control plans. Their work is built around our periodic plant-wide industrial hygiene surveys and special investigations. Each plant program is sufficiently flexible that any need that arises may be brought under it for control. Periodically, progress reports are published for management review.

It is our aim to establish an annual operating budget for each plant's industrial hygiene program. With a budget plan, work can be accomplished with more speed than under a system of obtaining an appropriation for each item. Furthermore, responsibility is centralized and flexibility is insured. A valuable aid to such a program is a definite allocation of maintenance and construction man hours to install the improvements.

Air Pollution Prevention

Problems in air pollution prevention fall directly upon the industrial hygienist. His trace sampling and analytical determinations are needed for gathering factual data regarding new or existing processes. An important consideration of any new process is its potentiality for atmospheric pollution. When potential pollution exists the adoption of process changes may reduce or even eliminate it entirely. It may be necessary to resort to condensing, trapping or scrubbing to avoid pollution.

Because of our constant contact with process development engineering, a vent on a blueprint is no longer indicated by an arrow pointing upward, or a discharge to the sewer by an arrow pointing downward. Instead, vent lines now may show condensing, scrubbing or trapping equipment or, in the case of hydrogen sulfide, some form of incineration. Thinking in terms of preventing air pollution naturally extends to the consideration of preventing effluent problems.

The program in one of our plants serves as an example of air pollution prevention. Our policy is to obtain first hand information about our "airfluent" problems without waiting until someone else calls attention

to them. Routine sampling of vent stacks from the top of operating buildings provides information on the chemical nature and the extent of discharged substances. The sampling indicates if our control measures are working satisfactorily and discloses at once any new problems which may develop. In the manufacture of sulfuric acid, our rapid SO_2 micro stack sampling technique may be used as an indication of operating efficiency. Also our micro test for NH_3 in a vent stack has served as a control of a process reaction when no other rapid indicatory evidence was available. This type of work is usually done by plant chemists under our direction who have been equipped to handle some of our air sampling work.

Process Control

There are many small laboratories for process control in a chemical plant. We find that the chemists are extremely interested in the rapid micro techniques of the industrial hygienist for sampling and analysis. They save both time and cost but more important from our viewpoint, are the changes that have occurred in the methods of obtaining samples. With these micro tests a few milliliters of the substance will be sufficient for analysis and it is no longer necessary to obtain a one or two liter sample. Attention has been given to the habits of sample takers, particularly when the more toxic substances are handled. In these cases, we prefer that the sample be collected by vacuum technique rather than by opening the manholes on reaction kettles for dip sampling with a consequent possibility of exposure to gas or vapor.

As industrial hygienists for the American Cyanamid Company, we have occasion to translate the information from the toxicologist's notebook into terms more readily understandable by plant supervisors and employees. Our translations develop into publications that outline safe working procedures. These publications, in turn, have been used in job training, particularly when the more toxic substances are involved.

Ready Availability of Services

In a few of our plants it has not been necessary to maintain full-time personnel under the industrial hygiene program. Periodic surveys suffice, but between times, the plant manager or an engineer serve as our liaison representative in matters of industrial hygiene. They advise us of changes to be made or of environmental problems that arise. It is their habit to submit blueprints of proposals for our review. We feel that we are only on the other end of the telephone from any person in any of our plants, and in actual practice this certainly is the situation. These frequent calls extend our usefulness and make it possible for us to be of immediate aid; a situation that does not exist where a formalized approach is demanded.

We are in constant touch with the company's central engineering department, particularly the ventilation and air conditioning section. They have established a review procedure covering industrial hygiene and including sanitation, general ventilation and illumination. The central office process development engineers confer with us on new processes so that the proper measures for maintaining a satisfactory working environment for our employees can be designed at the blueprints stage.

Our contact with the central safety department and plant safety groups is also continuous. The two fields of safety and hygiene are, as you know, very closely connected but we have a definite division of responsibility between them. The two fields are very close in recommendations dealing with personal protective equipment. The industrial hygienist assumes direct responsibility in the matter of recommending the type of respiratory protection. However, both groups recommend protective clothing, including goggles, where the need occurs in their particular area of responsibility.

On occasion we have worked closely with the legal department of the company in providing factual data and information for their use and guidance in the consideration of industrial hygiene matters.

It is through this cooperation with and by the various company-wide groups that practical and worthwhile accomplishments have been made. This cooperation in a large measure serves as the basis of our educational program; it has given us the chance to point out the needs and opportunities in the field of industrial hygiene to many persons who do not as a rule come in direct contact with the man on the plant operating floor.

Our cooperation with the various sales groups and their technical service representatives has brought us gratifying experiences. We discuss problems with them concerning the use and handling of our products by customers and, not infrequently, travel with them to our customers' plants. The excellent reception accorded us by our customers points to their concern for maintaining the health and safety of their own employees. Occasionally, it has been possible to allay unfounded fears and misgivings on the part of others and it has been a pleasure to see our suggestions and recommendations acted upon and improvements made in their workplaces.

It is not necessary to discuss in detail the many other related activities which are a part of any industrial hygiene program. It will suffice to mention that we constantly seek development of new and more successful sampling and analytical techniques, so that more "on the spot" evaluations can be made and routine information gathered that will insure the continuance of good working conditions.

The industrial hygienist, in common with most of humanity, derives satisfaction from seeing the benefits which result from his efforts. He is pleased to hear employees praise a good working environment for which he knows he is partly responsible. He is also gratified to hear from the department head that production has been increased due to improved working conditions.

From this brief outline of Cyanamid's industrial hygiene program it will be apparent that the major premise upon which the program is based, that is, to provide better and more healthful working conditions, is related directly to our company's policy concerning its employees and the environment wherein they are at work.

New England Annual Meeting

THE PROGRAM for the annual meeting of the New England Section of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION to be held in Boston on October 28 will be as follows: Morning Session: Chairman, JOHN B. SKINNER, Director, Division of Occupational Hygiene, Massachusetts Department of Labor; "Composition of Nitrous Fumes"—H. A. WAKE, DR. H. B. ELKINS and B. P. W. RUOTOLO, Massachusetts Division of Occupational Hygiene; "Air Hygiene in Tunnel Construction Operations"—HAROLD BAVLEY, Massachusetts Division of Occupational Hygiene; "Air Pollution Problems"—DR. F. J. VINTINNER, Division of Industrial Hygiene, New Hampshire State Board of Health; "The Role of Porphyrins in the Diagnosis of Lead Poisoning"—DR. CLARENCE MALOOF, Massachusetts Division of Occupational Hygiene and a speaker to be announced. Afternoon Session: Chairman, E. WARD THOMPSON, American Mutual Liability Insurance Company; "An Analysis of the Concept of Accident Proneness"—DR. ROSS A. MCFARLAND, Department of Industrial Hygiene, Harvard School of Public Health; "A Case of Poisoning from Cadmium Bearing Solder: Clinical Aspects"—DR. ROBERT ADAMS, Assistant Resident, Medical Service (Tufts), Boston City Hospital; and DR. ALBERT O. SEELER, Department of Industrial Hygiene, Harvard School of Public Health and Thorndike Memorial Laboratory, Boston City Hospital—Environmental Aspects—B. P. W. RUOTOLO, Massachusetts Division of Occupational Hygiene; "Wet Methods of Air Cleaning"—GEORGE S. REICHENBACH, JR., Department of Industrial Hygiene, Harvard School of Public Health; "Factors in Determining Exhaust Requirements for Solid Materials Handling"—RICHARD DENNIS, Department of Engineering, Harvard University.

Public Health Aspects of Atmospheric Pollution

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WHEREVER human beings congregate there is atmospheric pollution. If we did nothing else but breathe, we would contribute to the contamination of the atmosphere .... for the air which we exhale has been changed in composition from that which we inhaled. But our mode of living causes us to contaminate the atmosphere even more. Our modern civilization requires us, for example, to heat our homes and cook our foods; our industries, and our public transportation facilities all add to the general atmospheric pollution. We cannot even take our families out for a Sunday drive without aggravating the situation. I present these facts to you to indicate the universality of the problem as well as its complexity. In order to visualize its many facets, let us analyze two of the broad phases of the problem, namely, (1) effects, and (2) contaminants.

Effects

THE EFFECTS may be considered under the heading of (1) nuisance, (2) economics, (3) vegetation, (4) animals, and (5) health. While this paper deals with the public health aspects of atmospheric pollution, these are not the only phases of the problem; and in many cases they are not the most significant. Therefore, brief mention is made of some of the other aspects in order to look at the health phase in relation to the problem as a whole.

Nuisance: The nuisance aspects of the atmospheric pollution problem are well known. Obnoxious odors, loss of visibility, and the dirt of settled particulate matter have been experienced by practically everyone.

Economics: Another familiar effect of atmospheric pollution is discoloration of buildings, including stone, brick and painted surfaces. Blackened surfaces and encrustations of soot material frequently obliterate essential lines and decorations. They literally disfigure a building and seriously reduce its aesthetic and decorative value. More serious, however, is the corrosive action of acid gases on buildings. One of the effects of this reaction is the formation on stone surfaces of hard, impermeable skin which tends to blister and exfoliate. It has been reported that sheets of galvanized iron had a life span of 3-6 years in Pittsburgh as compared with 7-14 years in a smoke-free community; and that copper would last only 10-20 years in Pittsburgh, whereas it would be good indefinitely where there is relatively little atmospheric pollution. The effect is well known of certain acid gases on paint, as exemplified by the blackening of white lead base paint by hydrogen sulfide.

Vegetation: The civic beauty of a community is often reflected in the upkeep of its parks and the landscaping of its homes. The farms at its outskirts also are an essential part of a prosperous community. The effects of atmospheric pollution on vegetation are therefore an important consideration. A polluted atmosphere may injure plant life more than it harms animal life. The effects of polluted air are shown by stunting in growth, loss of vigor, reduction in crop yield and degradation of color. Sunlight is more directly essential to plant life than to other forms of life for the plant depends on the light falling on its leaves for the conversion of carbon dioxide to the carbohydrates that largely make up its substance. In other words, light is as essential to plants as carbon dioxide. On an annual basis the light reduction caused by pollution in the atmosphere may be up to 40% or 50%. Further loss is experienced by the plant because the coating of particulate matter that accumulates on its leaves makes it increasingly difficult for the life-giving rays of the sun to reach the leaf. This coating of particulate matter on the leaf surfaces also tends to choke the minute openings of the leaf through which the plant breathes. Particulate matter

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causes further damage to the living cells and destroys chlorophyll by holding the acid gases in the atmosphere in contact with the leaf. In many cases the leaves and tender plants are scorched beyond recovery. Further, increase in acidity of the soil due to atmospheric pollution can adversely effect vegetation.

Animals: Evidence is available which indicates that animals are affected by atmospheric pollutants. The Donora investigation revealed that dogs manifested acute toxic effects during the prolonged smog conditions. There was some evidence to indicate that other species of animals were also affected.

Another effect that is not as dramatic but nevertheless important is that resulting from the ingestion of contaminated vegetation. Studies have indicated that although the concentration of a particular contaminant in the atmosphere might not be present in sufficient quantities to produce injurious results to livestock by inhalation, an accumulation or deposit of the contaminant on vegetation eaten by animals may result in lowering the vitality, stunting growth, and could eventually lead to death.

Health: For the purpose of this discussion, the problems of airborne disease of biological etiology, and airborne diseases of plant origin (such as allergies) will not be considered. The discussion will be limited to diseases caused by air-borne dust, fume, and gas—all products of our civilization.

Since the thirteenth century, attempts have been made by various investigators to show the relationship between atmospheric pollutants and illness. The results of these investigations were either inconclusive or the claims could not withstand the close scrutiny of the medical profession. Therefore, the majority of the medical men looked upon atmospheric pollution primarily as a nuisance and not a health problem.

As a result of the Donora episode, the question has again arisen: *Is atmospheric pollution a health problem?* To answer this question one must consider the problem from the viewpoint of both acute and chronic effects. For the acute phase, the answer is definitely in the affirmative. Our investigation into the Donora episode indicated that people died and thousands became ill during the prolonged smog conditions.

It is not simple, however, to determine what the effects on the populace are of long-term exposure to atmospheric pollution. If these effects are to be ascertained, we must have answers to certain questions, such as: (1) What effect does atmospheric pollution have on persons with pre-existing maladies such as disease of the respiratory tract, heart disease, and possibly others? (2) What effect does atmospheric pollution have on elderly people who by the aging process naturally develop degenerative diseases of the lungs and heart? (3) What effect does atmospheric pollution have on children who have an increased respiratory rate as well as increased metabolism? (4) What effect does atmospheric pollution have in lowering the resistance of persons so as to predispose them to infectious diseases, particularly of the respiratory tract? (5) What effect does atmospheric pollution have on the mental health of individuals?

To answer these questions, it will be necessary to know more about the properties and effects of the contaminants themselves such as: (1) What concentration of contaminants is required to produce acute and chronic effects? (2) Does a combination of contaminants act individually? Is the effect additive, or is the effect greater than the summation of the individual effects? (3) Under what meteorological conditions would contaminants increase to harmful concentrations?

These and many other questions must be answered before one can adequately evaluate the long term effects of atmospheric pollution on the health of the general population. Only general knowledge is presently available, such as the fact that atmospheric pollution does decrease the quantity of the germicidal rays of the run and in this way may indirectly produce adverse effects. It is also known that irritating gases and large amounts of particulate matter present in the atmosphere may reach concentrations which would have an adverse effect. The extent of such injurious effects is not known.

Maximum allowable concentrations of many toxic substances have been established for protecting the health of workers in industrial plants. However, these concentrations have been established for the type of personnel normally employed in industry (aged 18-60 in relatively good health) dur-

ing the course of an eight-hour day. Hence, the maximum allowable concentrations familiar to industrial hygienists throw little light on amounts that can be safely breathed 24 hours a day by the general population, including the very young and the aged, as well as persons with organic diseases and those with special sensitivity to respiratory irritants.

It is important to emphasize that information available on the toxicological effects of mixed irritant gases is meager and that data on possible enhanced action due to adsorption of gases on particulate matter are limited.

To obtain the necessary data will require both laboratory and field work on an extensive and time consuming scale. Although these long-range studies are essential to the solution of the problem of atmospheric pollution, this does not mean that practical control procedures can not be carried forward in the meantime. It does mean, however, that careful thought and planning are necessary if orderly progress is to be made.

Contaminants

BEFORE an intelligent evaluation can be made of the atmospheric pollution problem, information, even though general, must be obtained on the contaminants found in an industrial community. For present purposes of simplification, the contaminants may be divided into two groups: (1) gases and vapors and (2) particulate matter.

Probably the most common gas found in the atmosphere is sulfur dioxide. Some of the other gases found in various amounts are carbon monoxide, carbon dioxide, hydrogen sulfide, oxides of nitrogen, hydrofluoric acid, hydrochloric acid, ammonia, and organic solvents.

Particulate matter is a term applied to dusts, fumes, mists and fogs. The size of particulate matter plays an important part. Large particles settle readily near the source of discharge under normal weather conditions. These particles are seen daily on the floor, window sills, and porches. The smaller particles, less than a micron in size, remain suspended in the atmosphere for an extended period of time. They are the particles that reduce visibility, shut out sunlight, and adhere to the ceiling, walls, and draperies. They are also, unfortunately, the most difficult to collect by known control procedures. They also serve as nuclei for the condensation of moisture resulting in fog. The types of particulate matter commonly found in the atmosphere are silica, silicates, fly ash, carbon, and the oxides of the various metals. The type of particulate matter suspended in the atmosphere depends on the types of industries present.

After classifying the contaminants found in the atmosphere, one next must consider the source or point of generation of these contaminants. Products of combustion, for example, emanate from such sources as manufacturing plants, homes, trains, boats, incinerators and brush fires. Industrial operations of virtually all types add to the general atmospheric pollution load, and automobile traffic, construction, and wind storms also contribute to the overall problem.

After atmospheric contaminants have been studied, the sources determined, and toxicological information reviewed, the next question is "What can we do about it?" The methods of control of various pollutants are many. The principles used are in the main: (1) substitution, (2) conversion, (3) collection, and (4) dilution. Let us consider these four principles to see how they apply in practice.

Substitution: This principle is well illustrated by the substitution of Diesel switch engines for coal-burning steam engines. Although substitution has a limited place in industrial operations, it may be used wherever practicable to effect a substantial reduction in atmospheric contamination. In the designing of a new plant where air pollution is a potential problem, this principle could be of primary importance.

Conversion: Conversion is a term applied to the process of converting, for example, an obnoxious substance to one that is not obnoxious. Thus, organic compounds are often disagreeably odoriferous and extremely annoying even in low concentrations. It is possible to convert such materials into substances which are not particularly objectionable by passing the offending material through furnaces for conversion into a less unobjectionable substance.

Collection: There are many types of collectors on the market today, among which are mechanical filters, cyclones, electrostatic precipitators, scrubbers and ultra-

sonic equipment. Each problem in the collection of atmospheric contaminants must be considered as a separate entity, and the engineer must take into account many factors before making recommendations. In some instances, installations have paid for themselves by the recovery and subsequent reclaiming of collected substances. However, we must bear in mind that this cannot always be expected, and that the sole benefit derived will be a decrease in atmospheric pollution.

Dilution: Dilution is a very practical control measure. It is well known that a substance can be annoying, even harmful, in certain concentrations. Yet the same substance can be diluted to a point where it is no longer objectionable nor injurious to a person's health. This dilution depends on the vertical mixing, turbulences and dissipation by the wind; hence, the science of meteorology can play an important role in this method of control. For instance, if a plant were located in an area where prevailing winds disperse the contaminants away from the inhabitants, there would be no problem so far as the human element is concerned. It is probable in the future that many companies before they erect a plant will consider the meteorology of an area, in addition to the availability of raw materials, labor, transportation, and other factors, before the erection of a plant.

In review, there are many known principles which may be applied to the control of atmospheric pollutants. However, it is not meant to imply that the control of contaminants is a simple task. Much is yet to be learned about the control of small dust particles, particularly in the size range of less than one micron. Additional information is needed on the removal of small percentages of contaminants from relatively large streams of air. At the present time, the cost of controlling some atmospheric contaminants is prohibitive. It is, therefore, a challenge to the engineering profession to devise methods to increase the efficiency and economy of equipment for the collection of atmospheric contaminants.

Ordinance

THE MAJORITY of the larger cities in the United States now have ordinances on smoke abatement and atmospheric pollution in general. In considering the adoption of an ordinance on atmospheric pollution the community should use ordinances from other cities only as a guide. The reason for this becomes obvious when you consider that no two cities are alike with respect to the various phases of atmospheric pollution problems.

Before an adequate ordinance can be adopted a thorough investigation into the problem is necessary. Consideration should be given to such factors as topography, and weather conditions, such as temperature, inversions, wind directions and velocity, and humidity. The type, extent, and locations of industries must be evaluated. The type of fuel used throughout the community is also an important consideration.

Successful atmospheric pollution abatement practices have shown the need for an active civic support. The support of chambers of commerce, womens' clubs and business and professional organizations is needed in molding public opinion for the abatement of atmospheric contaminants. Representatives of various industries, citizens groups, public officials, medical societies and engineering societies, should be represented on an advisory board to the atmospheric pollution department of the community.

Summary

THE PROBLEM of atmospheric pollution is much too complex to be covered in the brief time available, and only some of the highlights have been mentioned. It is a problem which is important to all of us—not only from the standpoint of its possible effects on us individually, but also as it effects our entire economy. The cooperative efforts of many groups will be required to obtain the basic information which is necessary if we are to develop a progressive atmospheric pollution program. Only by an intelligent, concerted approach to this problem can we hope to arrive at those reasonable conclusions which will permit industry the right of operation, and the community the right to have an atmosphere which is relatively free of atmospheric pollution.

Survey of Cemetery Memorial Industry in Indiana

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A SURVEY of the cemetery memorial industry in Indiana was undertaken for the purpose of determining to what extent workers in this industry might be exposed to silica-bearing dust. Since practically all monument work is with granite and since granite contains approximately 30% free silica it was felt that a silicosis hazard was potentially present. In no respect was the survey, including dust studies, undertaken with any intention of making a detailed research project.

Plant and Population Data

MONUMENT stone cutting in Indiana may be classified as a strictly indoor occupation even though a small amount of hand and pneumatic tool work is performed out of doors during summer months. The majority of shops operate all year. The cutting of dates on stones already erected in cemeteries of course is performed out of doors but is an infrequent occurrence and is usually done with the protection of a respirator plus an abrasive helmet. The mere fact that granite is cut out of doors with either hand or pneumatic tools does not relieve the danger of excessive exposure to the silica dust generated by the operation though in some cases the exposure would possibly be lessened by the action of drafts or a breeze.

TABLE I.
PERCENTAGE DISTRIBUTION OF MONUMENT SHOPS BASED OF NUMBER OF WORKERS PER SHOP

Workers	Shops	Percentage
2 to 5	103	86%
5 to 10	13	11%
10 or more	4	3%
358	120	100

The small number of workers found in the average Indiana shop tends to make job classification difficult. Workers will intermittently do selling, layout work, blasting, hand or pneumatic tool cutting or set foundations and stones in cemetery. Because of the intermittent stone cutting periods and job diversification it is impossible to estimate or even approximate a total dust exposure for any one individual.

Statistically the survey included every shop in the state where granite cutting is performed, a total of 120 shops.

Five of the shops perform manufacturing processes, i.e., take rough or bulk quarried granite and produce the finished stone as viewed in a cemetery. The other 115 shops purchase stones from both domestic and foreign quarries cut to size and shape and which require only the designing, lettering and engraving to complete the stone. There are no granite quarries in the state of Indiana.

Fig. 1.
Vision window in movable curtain of blasting room

Reprinted from the *Indiana State Board of Health Monthly Bulletin*, May, 1949.

Fig. 2.
Pneumatic hand tool work with banker type dust collector in use

Fig. 3.
Pneumatic hand tool work without dust collector. Note excessive dust

Processes and Operation

BLASTING is universally performed in all monument cutting shops and creates one of the significant dust exposures now existing in the industry. The surfaces of stones to be blasted are covered with a rubber or plastic compound, the lettering and designs are traced or transferred to this surface, and the parts to be blasted are cut out, exposing the stone surface. The stone is then placed in the blasting room and the operator stands on the outside and directs the abrasive blasting nozzle through a curtained opening at the pattern, observing the progress of the work through a vision window. These windows are invariably covered with a fine mesh wire screen to protect operator's face from rebounding abrasive particles. Commercial blast room windows in addition to the screen on the inside wall of blast room are fully covered with glass on outside wall. The screen prevents any rapid etching of the glass caused by rebounding abrasive particles and the glass provides excellent protection from dust. The glass in the windows is usually in small sections set in place so they overlap slightly, the edges being anchored by heavy rubber strips. Fig. 1 illustrates this type window installation. There is little if any dust leakage around such window and the small sections of glass make replacement a minor and inexpensive problem.

Below the window in blasting rooms is usually a long port or slot through which the abrasive blasting nozzle is manipulated. Sometimes this opening is covered by overlapping strips of heavy rubber which effects a satisfactory seal against dust leakage and rebounding abrasive particles, and does not obstruct in any way the movement of the abrasive blasting nozzle. In too many cases this opening is covered by light canvas drapes which do not effect a good seal against dust leakage or rebounding particles, and further the canvas is rapidly abraded into complete ineffectualness.

The use of sand for abrasive blasting of ornamental designs and lettering on the surface of granite monuments is still widespread and creates more of a potential silica dust hazard than through the use of artificial abrasive. Since blasting sand itself is very high in free silica, dust concentrations must be held to much lower levels where sand is used. Artificial blasting abrasive contains no free silica.

In 19 of the 120 monument shops an additional blasting room is maintained in which shape carving is performed using steel shot as the abrasive. Certain desired ornamental effects that cannot be secured by means of the ordinary abrasive blasting apparatus are obtained by using steel shot discharged through a much smaller nozzle, held in the hand like a pencil and the manip-

Fig. 4.
Cleaning work through the use of compressed air from the base of the pneumatic hand tool. Note excessive dust

ulation of which requires a good view of the work at close quarters. The operator doing this usually works within the blast roo mitself protected with a supplied air helmet or a respirator plus a helmet to protect face from rebounding steel shot.

While generally there is a small amount of pneumatic hand tool work performed by Indiana monument workers this operation gives rise to excessive dust exposures, if uncontrolled, which endangers not only the operator but anyone else in the workroom. The dust generated by the use of pneumatic hand tools is quite readily controlled by use of a banker type local exhaust dust collector. Nineteen shops are provided with this type dust collecting apparatus while 95 shops have no such controls. In many of the 95 shops however none of this work, or very little, is ever done.

The banker type dust collector consists of a flanged metal exhaust hood connected to a flexible hose which usually is connected to blasting room exhaust system. The metal exhaust hood is moved freely about over work area but to be effective must be kept within a short distance of the pneumatic hand tool. See Fig. 2. Fig. 3 illustrates the potential dust hazard in pneumatic hand took work where no exhaust is used, while this exhaust system is effective in removing dust generated by the normal use of pneumatic hand tools it will not control the dust generated when compressed air is released from base of pneumatic tool to clean working surface of grit and dust. This is a poor practice but a very common one among workers doing this type of work. Fig. 4 shows the excessive dust generated when work is cleaned by compressed air.

While the banker type dust collector is the most efficient method of controlling the dust generated by the use of pneumatic hand tools, it constitutes an expensive piece of equipment in many shops because of its infrequent use. In the absence of mechanical control of dust generated by pneumatic hand tools some excess dust can be controlled by wetting the stone area being cut, with kerosene or turpentine. Applications must be frequent enough however to keep surface well wetted and few workmen will follow this practice. If the kerosene or turpentine is clean it will dry and leave no stain but in the presence of a heavier oil or other contaminant may stain the granite. Such objections were heard, pertaining to this wet method of dust control.

In the five shops performing manufacturing processes the most serious dust generating operation not included in every other shop is surfacing. Surfacing is performed dry and generates excessive dust. In four of the five shops this operation is locally exhausted.

Surfacing is the cutting of a relatively smooth surface on rough granite using, first, heavy point tools in a surfacing machine and progressively using smaller point tools. The stone surface may be finished to the desired degree by using bush hammers with progressively more blades and operated in a surfacing machine or by pneumatic hand tools.

Results of Study

BLASTING rooms were examined during the survey of almost every conceivable type, size and construction; from mere hanging drapes of canvas to the modern steel commercial blast room. Obviously dust exposures are in direct relation to the measures of dust control in practice. Table II illustrates the desirability and need for further improvement in blasting facilities.

It is imperative that blasting rooms be so constructed as to prevent dust leakage during blasting. Evidence of dust leakage is almost universally discernible around a blasting room by a layer of dust on structure and equipment.

TABLE II.
CONSTRUCTION OF BLASTING ROOMS

	Satisfactory	Unsatisfactory
Blast Room Dust Tight Construction	120	19
Blast Room Window Entirely Glassed	86	53
Blast Room Exhausted to Dust Arrester	64	75

The use of approved Type A respirators by blasting operators is unnecessary when the blasting room is dust tight, has a fully screened and glassed vision window, a blasting port effectively sealed, and when there is adequate air movement through the blast room and exhausted dust cannot be blown back into workroom through open doors or windows. In the absence of any of the above controls or in the presence of visible dust then the use of a respirator is an advisable precautionary measure.

Table II shows there are 64 blasting rooms being exhausted to some type of dust arresting device and 75 that merely exhaust the dust through the wall or sometimes the roof of the building. The importance in controlling the dust exhausted from blasting rooms is to prevent the dust being carried by a draft or a breeze back into building or from becoming a neighborhood nuisance. There are isolated cases where dust discharged to the open air will cause no harm, but few monument shops are so located as to make this a good practice.

Cloth filter dust collectors have been found to be quite efficient in the granite industry in cleaning the dusty air though they do cause variations in pressure drop throughout the operating cycle. The pressure drop throughout the operating cycle. The pressure drop being at a minimum immediately after shaking filter bags and increasing as dust accumulates on cloth and air flow decreases. Fig. 5 shows an indoor installation on a cloth filter dust collector with manually operated shaker.

Dust samples were collected in 10% of the shops during dust generating operations. Sampling was done during winter months but weather was sufficiently mild that in most cases shop doors and windows were either fully or partially open. This conditions points toward lower dust levels than during periods of extreme cold weather when doors and windows are kept closed.

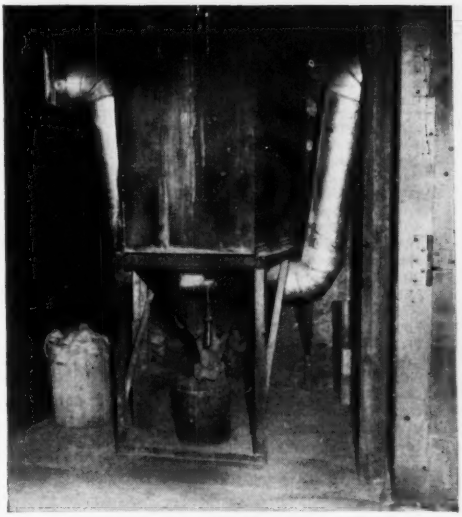

Fig. 5.
Cloth filter dust collector with manually operated shaker

The technique in collecting and counting of dust samples followed the standards recommended by the U. S. Public Health Service. All dust counts were made within 24 hours of collection.

Settled dust samples were collected and chemically analyzed for free silica in all shops where dust sampling was done providing dust was available on structure and equipment. A few of the shops were actually so clean that it was impossible to collect enough settled dust for analysis.

As a result of studies conducted in various places maximum allowable concentrations of silica bearing dusts have been established by American Conference of Governmental Industrial Hygienists as follows:

A comparison of Tables IV and V clearly indicates the necessity for more rigid dust control where sand is used as blasting abrasive.

Interpretation of Results

WHILE it would be obviously unwise to draw conclusions from single dust samples or so very few, it is felt they should at least be used as indicating at the present time specific local conditions. The reason so few dust samples were collected in some of the dust generating operations illustrated

TABLE III.
DUST COUNTS IN INDIANA GRANITE CUTTING SHOPS

Location and Number of Sample		MPCF*
1. Near operators of blasting rooms with fully glassed vision windows..	12	10.4
2. Near operators of blasting rooms with non-glassed vision windows	4	11.7
3. Near operator of blasting room with pneumatic chisel operating without exhaust about 20′ distant	1	44.0
4. Inside blasting room 1 minute after shutting off blast to inspect work	1	151.0
5. Near operators using pneumatic hand tools without exhaust.....	2	134.0
6. Near operators using pneumatic hand tools with local exhaust....	2	5.3
7. Near face of workmen cutting granite with hammer and hand chisel (no exhaust).....	1	17.4
8. Near surfacer with local exhaust	2	8.0
9. General atmospheric samples of workrooms during blasting.....	3	5.8
10. General atmospheric sample of workroom with pneumatic chisel operating (not exhausted).....	1	31.6
11. General atmospheric sample of workroom with pneumatic chisel operating (exhausted)	1	3.4

* Million Particles Dust Per Cubic Foot of Air.

TABLE IV.
FREE SILICA ANALYSIS OF SETTLED DUST IN INDIANA GRANITE SHOPS

	Number of Analysis	Average Free Silica Content
Artificial blasting abrasives.....	3	18%
Sand as blasting abrasive.....	5	68%

TABLE V.

	Maximum Allowable Dust Concentration*
Dust containing above 50% free silica....	5
Dust containing 5 to 50% free silica....	20
Dust containing below 5% free silica....	50

* Millions of particles of dust per cubic foot of air

in Table III is further indication of the intermittency of operations and the difficulty of finding the various operations in progress simultaneously, or even during the same work day.

The data presented above, though limited in scope, is merely intended to be helpful to the monument industry in the practical application of dust control measures for the preservation of the health of granite workers. The survey discloses that the total dust exposure of the workers, while not capable of exact determination, is undoubtedly lower than the dust counts would indicate. This is because of the intermittency

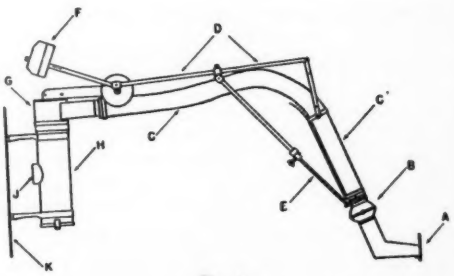

Fig. 6.
Diagrammatic illustration of a banker type dust collector. A, flanged hood; B, universal joint; C, rubber hose, 4 inch inside diameter; D, counterweighted hose support; E, telescoping friction rod; F, counterweight; G, revolving head; H, chip trap; J, dust connection to fan; K, wall or post support

of operation and the non-continuous exposure.

However, personal interviews disclosed silicosis being present in at least 10% of the Indiana shops and therefore, it is deemed advisable for every plant to practice every possible precautionary dust control measure.

Recommendations

THE following recommendations are generalized but are essentially the same as those made in individual cases:

1. From a medical standpoint all workers in this industry should receive a pre-employment x-ray of the chest, and this examination should be repeated periodically throughout course of employment. Pre-employment x-ray examinations permit the exclusion of individuals who show evidence of active pulmonary tuberculosis. Periodic x-ray examinations provide the best check on workers in determining early lung involvement or complications. Workers showing evidence of early silicosis uncomplicated with infection should be allowed to continue at their work provided dust concentrations are reduced to safe limits. Workers showing evidence of silicosis complicated with infection should be removed from the industry and treated for their tuberculosis.

2. Engineering control measures seek to prevent the dissemination of harmful quantities of dust throughout the workroom, thereby preventing its inhalation by workers. The maximum allowable concentrations

of silica bearing dust considered as safe during a normal work day exposure are illustrated in Table V. While the majority of Indiana granite cutting shops provide a worker an intermittent exposure it is felt that dust concentrations should wisely be held to the limits mentioned in Table V.

(a) Blasting rooms should be of dust tight construction and where air inlets are provided they should be properly baffled. The curtain should be of sufficiently heavy material to resist rapid abrasion and should fit well enough to prevent dust leaks. The blasting port should be covered by overlapping strips of heavy rubber in all cases where blasting nozzle is not bolted in a fixed position. Vision windows should be fully screened on inside wall of blasting room and fully glassed on outside wall next to operator's face. Blasting room exhaust systems should provide minimum air velocities of 500 linear feet per minute through all openings to blast room. Blasting rooms should have a minimum of 20 air changes per minute.

Blasting room exhaust system should discharge so as to prevent dust being blown back into workroom. Except in extremely isolated cases this will mean provision of a dust arrestor of some type. Proper maintenance of all parts of an exhaust system is equally as important as proper installation, therefore, the system should be periodically checked.

Artificial blasting abrasive should be used if at all possible because the abrasive itself contains no free silica.

The practice of entering blasting room, immediately after shutting off blast nozzle, to examine work should only be done while wearing an approved Type A respirator.

(b) Pneumatic hand tool work should be provided with local exhaust ventilation for greatest efficiency in controlling the dust generated by this operation. The banker type dust collector, when properly used, has been shown to be capable of keeping the dust concentration within safe limits.

The quantity of air which must be withdrawn depends on the size and shape of the hood. Generally these hoods approximate 18 to 24 square inches of rectangular opening with a three-inch flange on top and both sides. With such a hood it is necessary to withdraw not less than 400 cubic feet of air per minute with the tool operating not more than six inches from hood. If the tool is 10 inches from hood 600 cubic feet of air per minute is required. The duct velocity should be 3300 to 4000 feet per minute beyond the trap slide, and 5500 to 6000 feet per minute before trap. A chip trap should be present.

The widespread practice of cleaning working surface of stone using the compressed air which operates pneumatic tool is to be discouraged. Working surface of stone should be cleaned with a brush, brushing toward exhaust hood.

Pneumatic hand tool work is performed so infrequently in many shops that installation of a dust collector would create unjustifiable expense. In all shops where this work is done infrequently and is of relatively short duration the work should be isolated from any other workmen and operator should wear an approved Type A respirator during exposure.

Wet methods are generally unsatisfactory and are not recommended as a dust control measure in pneumatic hand tool work.

(c) Granite surfacing should be provided with local exhaust ventilation of much the same type as in pneumatic hand tool work, the exception being that the exhaust hood should encircle the tool.

Figs. 7 and 8 illustrate two commercial forms of surfacing exhaust hoods.

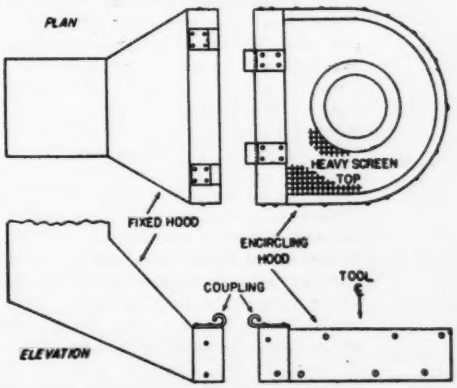

Fig. 7.

A commercial form of hood with encircling section for use during four-pointing. The detachable encircling hood is linked to the fixed hood by means of a pin (not shown) that passes through the loops of the coupling. With this hood the distance from the coupling to the center line of the tool is five inches

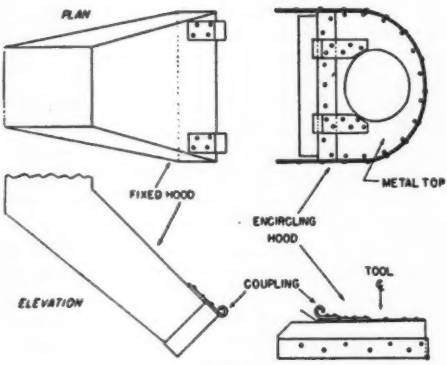

Fig. 8.

Another commercial form of hood generally similar to that shown in Fig. 7. In this case the distance from the coupling to the center line of the tool is three inches which is the closest that the tool center can come to the edge of the fixed hood and still provide enough clearance for the bush hammer. This smaller distance is an advantage over the arrangement shown in Fig. 7. The metal top shown here is also sometimes preferred as more effectively shielding the operator's face from flying chips

The volume of air to be exhausted for satisfactory control of dust generated in surfacing is 500 cubic feet per minute with a branch duct diameter of four inches and with a tool diameter up to 2⅜ inches; 1000 cubic feet per minute with a branch duct diameter of 5½ inches and with a tool diameter of 2⅜ inches to 2⅞ inches.

(d) The general use of respirators in lieu of dust control measures is not recommended and should be limited to short periods of exposure when other dust control methods are impracticable.

(e) A good general exhaust system of ventilation for workrooms, good natural ventilation, good housekeeping practices and especially a dust consciousness on the part of all granite workers are essential measures toward lowering the silica dust hazard in the monument industry.

References

1. Recommended Respiratory Protective Devices. *Indiana State Board of Health Monthly Bulletin*, 1944.

2. *Safety in Sandblasting, A Manual*, Industrial Hygiene Foundation of America, 1948.

3. HEMEON, WESLEY C. L.: Dust Control in Granite Cutting Industry. *Heating and Ventilating*, June, 1940.

Industrial Hygiene Foundation Meeting

THE FOURTEENTH Annual Meeting of the Industrial Hygiene Foundation of America will be held at the Mellon Institute, Pittsburgh, November 16, 17, and 18. The engineering conference under the chairmanship of PROF. PHILIP DRINKER will include the following: Ventilation for Relief of Industrial Heat; Demonstration by Model of Influence of Radiant Heat"—W. G. HAZARD and K. G. DUNN; "Mechanical Vibration and Worker Health"—KENNETH M. SMITH; "Equipment and Procedures for Stack Dust Sampling"—A. H. ARBOGAST and JOHN KANE; "The Engineering of Factories for People at Work"—J. K. GANNETT; "Corrosion-Resisting Materials for Some Exhaust Systems"—J. W. MCWILLIAMS; "The Behavior of Dust and Fume Particles as Regards Selection or Design of Dust Collectors"—STYG SLYVAN, and other papers. At the chemical conference under the chairmanship of HENRY F. SMYTH, JR., will be: "Relation of Particle Size to Retention of Particulate Matter in the Lungs"—JACK H. BROWN and THEODORE F. HATCH; "Atomic Oxygen at the Surface of Freshly Crushed Silica"—W. A. WEYL; "Skin Absorption of Chemicals"—NORTON NELSON; and "Misuse of Common Solvents"—E. M. ADAMS, M.D. Of greatest interest to the industrial hygiene group at the legal conference will be: "Rules and Regulations Relating to the Control of Occupational Hazards"—J. J. BLOOMFIELD, and "Industrial Application of Audiology"—L. G. DOERFLER. The conference on industrial wastes will include "The Chemistry of Smog"—H. H. SCHRENK; "Procedures for Determining the Magnitude of Air Pollution"—W. C. L. HEMEON, and other papers. The keynote address will be presented before the Annual Meeting by M. E. COYLE, Executive Vice President, General Motors Corporation, on the subject "Influences that Retard Industrial Development."

American Industrial Hygiene Association

—News of the Local Sections—

Chicago Section

AIR POLLUTION was the subject discussed by DR. A. D. SINGH, President, Singh Company, Consulting Engineers, Chicago, on September 7. DR. SINGH is chairman of the Research Committee on Air Pollution of the Smoke Prevention Association of America.

The meeting on October 5 is to be addressed by L. F. WEBER, M.D. Dermatologist, Chicago, on the subject "Occupational Diseases of the Skin." DR. WEBER, who has had wide experience in this field, is to present a number of color slides illustrating the subject.

Officers of the Section for the 1949-1950 year are as follows: President, HERBERT T. WALWORTH, Lumbermens Mutual Casualty Company; President Elect, L. E. HAMLIN, M.D., American Brake Shoe Company; Secretary-Treasurer, E. D. SALLEE, American Can Company. The Board of Directors is composed of the following members: EDWARD H. CARLETON, M.D., Inland Steel Company; WARREN A. COOK, Zurich Insurance Companies; HARRY G. GRAGG, American Air Filter Company; JOSEPH A. HOUGHTON, Liberty Mutual Insurance Company; JOSEPH A. HUBATA, M.D., Armour & Company; K. M. MORSE, Illinois State Department of Health; CARL M. PETERSON, M.D., American Medical Association; C. O. SAPPINGTON, M.D., DR. P.H., Industrial Health Consultant; WALTER F. SCHOLTZ, Allis-Chalmers Mfg. Company; ARVID TIENSON, Illinois State Department of Labor; FLOYD VAN ATTA, PH.D., National Safety Council; HERBERT J. WEBER, American Brake Shoe Company; JOHN W. YOUNG, International Harvester Company.

Metropolitan New York Section

THE September 27 meeting is to be addressed by HENRY FIELD SMYTH, JR., PH.D. on the subject "Study of New Chemicals in the Toxicological Laboratory." A short movie is to be presented showing glimpses of range-finding technic. DR. SMYTH is associated with the Mellon Institute of Industrial Research and is engaged in the study of the toxicological properties of the newer chemicals under a fellowship supported by Carbide and Carbon Chemicals Corporation.

The officers of the Section for the 1949-50 year are as follows: Chairman, LEOPOLD SCHEFLAN, PH.D., Pyrene Manufacturing Company; FREDERICK W. SANDS, U. S. Rubber Company; LEONARD J. GOLDWATER, M.D., Columbia University, School of Public Health; JOHN J. FERRY, Metropolitan Life Insurance Company and Councilors: CHARLES B. FORD, N. Y. State Department of Labor, Division of Industrial Hygiene and Safety Standards; WILLIAM B. HARRIS, Medical Division, U. S. Atomic Energy Commission; WILLARD MACHLE, M.D., Consultant; THOMAS W. NALE, M.D., Union Carbide & Carbon Corporation.

Northeastern Ohio Section

OFFICERS elected for the 1949-50 year are as follows: Chairman, WILLIAM L. WILSON, Bureau of Industrial Hygiene, Cleveland, Ohio; Vice-Chairman, E. O. KUMLER, American Steel and Wire Company, Cleveland, Ohio; Secretary-Treasurer, WILLIAM E. MCCORMICK, B. F. Goodrich Company, Akron, Ohio; Directors: BENJAMIN J. TEPPER, Government Chemical Products Company, Cleveland, Ohio; A. C. SHERRILL, Columbia Chemical Division, Pittsburgh Plate Glass Company, Barberton, Ohio; TOM J. CAIN, JR., B. F. Goodrich Company, Akron, Ohio; RUSSELL FRANK, Ferro Enamel Corporation, Cleveland, Ohio.

Pittsburgh Section

AMONG the personnel changes in this area are the appointments of THEODORE F. HATCH and ADOLPH G. KAMMER, M.D. to the faculty of the Graduate School of Public Health, University of Pittsburgh. MR. HATCH is to be Professor of Industrial Health Engineering at the new school and is to continue as Research Director for the Industrial Hygiene Foundation of America on a part time basis. DR. KAMMER is to be Professor and Head of the Department of Occupational Health. He leaves the position of General Medical Director of the Carbide and Chemicals Corporation, South Charleston, West Virginia to accept this appointment.

DR. H. H. SCHRENK is to join the staff of the Industrial Hygiene Foundation after a long association with the U. S. Bureau

of Mines Experiment Station in Pittsburgh and more recently with the United States Public Health Service.

Both MR. HATCH and DR. SCHRENK are past presidents of the American Industrial Hygiene Association.

A. Victor Nasatir, M.D.

THE sudden death of DR. A. VICTOR NASATIR on August 5, 1949, was a shock to all who knew him. DR. NASATIR has been closely associated with the administrative phases of industrial hygiene since he established the Division of Industrial Hygiene in the Los Angeles City Health Department in 1939. Excepting for the four years spent in military service, he occupied the position of Director of this Division until the time of his death. During the war, DR. NASATIR was commissioned as Captain in the Medical Corps with his first assignment as Industrial Medical Director at Ogden Arsenal. He was then sent overseas as Chief of Public Health, Headquarters First Army, and was awarded many honors for meritorious service, including the Bronze Star. The Republic of France bestowed upon him the Croix de Guerre with Silver Stars in appreciation of his achievements in re-establishing civilian health and medical services in war-torn areas. He was released from service on January 11, 1946, with the rank of Lieutenant Colonel. His professional memberships included: Fellow, American Medical Association; Fellow, American Public Health Association; American and Western Associations of Industrial Physicians and Surgeons; American Association for Advancement of Science; American Industrial Hygiene Association; American Conference of Governmental Industrial Hygienists; Southern California Industrial Safety Society. In several of these associations he served as an officer or on the executive committee. DR. NASATIR was widely known and well liked everywhere. For the high standards he set in his profession and for his personal qualities of kindliness, modesty, and consideration, DR. NASATIR will be deeply missed by his friends and associates throughout the country.

Paul Albert Brehm, M.D.

PAUL A. BREHM, M.D., Director of the Industrial Hygiene Division of the Wisconsin State Board of Health died suddenly on April 30, 1949. Only ten days before, he had greeted his many friends of the Mid-West area at a local section meeting of the American Industrial Hygiene Association.

In Wisconsin DR. BREHM had been head of the Division since its inception in 1937 and had gained wide acknowledgment for his accomplishments in furthering industrial health. He served as a member of the University of Wisconsin Medical School faculty and was Vice President of the Wisconsin Council of Safety.

Nationally, DR. BREHM was recognized as a leader in the field, and was past president of the American Conference of Governmental Industrial Hygienists. Industrial hygiene people throughout the country are among those who miss him personally as well as professionally.